FluidForming

Hydroforming Reinvented

METAL FORMING FOR THE 21ST CENTURY.
WE ENABLE INNOVATION

FLUIDFORMING AMERICAS

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Introduction and Abstract: What is FluidForming?

FluidForming Americas (FFA) is pleased to introduce an industry-changing and modern take on legacy bladder type hydroforming. FluidForming represents the first major innovation in metal forming technology and the first new alternative to metal stamping in more than 60 years. FluidForming technology differs from traditional metalworking processes like hydroforming and die casting in several important ways, all of which reduce product time to market and cost to market.

The FluidForming technology is an alternative sheet metal forming approach and differs from traditional, bladder-based deep draw hydroforming, hydro-mechanical, metal spinning, and sheet metal stamping in several significant ways. First and foremost, the self-contained construction of the FluidForming machine, the FormBalancer, allows for much higher forming pressures. With pressures of up to 400 mPA/60,000 psi, greater detail can be achieved and complex geometric shapes can be formed. Because of the bladder-free design and high forming pressures, the technology enables even material flow into the die which results in a stronger component than conventional metal forming processes.

The development cycle can be accelerated to less than a week from CAD design to the production of highly accurate, repeatable metal parts.

History of Hydroforming and the Birth of FluidForming

Hydroforming is a cost-effective way of shaping conventional ductile metals such as aluminum, brass, steel, and stainless steel as well as todays more sophisticated alloys into lightweight, structurally stiff, and strong pieces. The automotive, aerospace, medical, and appliance industries frequently turn to hydroforming to create strong, complex shapes.

Hydroforming, specifically sheet metal hydroforming, is a process based on the 1950s patent for hydramolding by Fred Leuthesser, Jr. and John Fox of the Schaible Company of Cincinnati, Ohio[1]. J. Squires was awarded a 1934 patent for propeller blade forming and in 1941, A. Odenwald[2] was awarded a patent[3] for high-pressure tube forming.

1 F.W. Leuthesser, Jr., J.A. Fox, US Patent 2,713,314 (1955)
2 J. Squires, US Patent 1,943,560 (1934)
3 Odenwald, German Patent DE710912 C (1941)

Multiple variations of the first version of sheet metal hydroforming (which was patented in 1955) exist today. Typically, these legacy methods operate with forming pressures in the range of 70-100 mPA/10,000-15,000 Forming of sheet metal is traditionally achieved by pressurizing a flexible bladder which in turn expands against the sheet metal that is being formed. A mechanical containment structure ensures that the liquid pressure forms the sheet metal into or over a single mould or die to achieve the desired shape. Tube hydroforming traditionallyrequires two moulds, but no bladder as the forming fluid is pressurized into the tube which in turn, deforms to fit the die[4].

The FluidForming technology was patented in Germany in 2000. This modern, bladderless reinvention of the traditional hydroforming process utilizes water pressures up to 400 mPA/60,000 psi and achieves a greater degree of detail, strength, and repeatability. FluidForming was invented to fill the market gap for a higher quality, more accurate, faster, intrinsically repeatable, and affordable metal forming process. This new process is perfect for prototyping through mid-range production runs. This system offers enhanced design flexibility, vastly reduces capital costs, reduces time to market, and offers easy product branding.

Principles of FluidForming and an Introduction to the FormBalancer

FluidForming's bladder-free technology uses liquid tap water with forming pressures up to 400 mPA/60,000 psi. These pressures are significantly higher than any other hydroforming process currently available. (By comparison, forming pressures for standard, bladder-based hydroforming reach maximum levels at 100 mPA/15,000 psi.) Unlike die-stamping, only one tool is required and the prototype and production tool are the same.

The FluidForming process begins when the pressure pillow establishes clamping pressure and closing forces. These forces are uniformly distributed throughout the frame. Next, water is introduced into the patented, force-contained FluidForming FormBalancer machine with pressures of up to 400 mPA/60,000 psi. Tool and pressure plate remain plane-parallel even at maximum forces.

Depending on the geometry, the sheet metal blank is clamped into position or allowed to flow into the cavity in a controlled manner. The machine's higher pressures enable the material to flow into the die, providing an even distribution of material in critical areas. During the final forming stage the sheet metal rests, fully-formed, against the die surface without potentially damaging friction. The fully formed part, which is essentially free from spring-back, can now be removed from the machine.

4 "FluidForming — Hydroforming Reinvented," Jürgen Pannock, Reinhold Wesselmann, Andre Lückmann, and Paul R. Benny, (2015).

Because every facet of the forming process, from blank design to material flow to clamping pressure and forming volume and water pressure is variable and controlled, FluidForming achieves finer, more detailed results. Furthermore, the process can be automated or operated manually.

With a few simple modifications, the FormBalancer can transform from sheet metal forming to tube forming function.

The design of FFA's FormBalancer machine creates a floating tool structure or "pressure pillow" for the upper and lower die mounting fixtures. This innovative design allows for plane-parallel, self-alignment of the tools and provides a level (plane-parallel) seal surface with evenly distributed sealing forces. For these reasons, costly, friction-inducing bladders can be eliminated and higher forming pressures can be achieved.

To prevent leakage, protect metal surfaces, and ensure a tight seal around the sheet metal, a protective laser film or scratch prevention film is also utilized. In fact, typically the thin protective film utilized for material protection during shipping and handling is sufficient to prevent leakage. Seal performance can be further enhanced with a simple O-ring or, in certain instances, a custom metal seal design.

Advantages of FluidForming

FluidForming has many benefits and a number of clear advantages over legacy hydroforming and die stamping.

IMPROVED SURFACE QUALITY

Because of our high forming pressures and bladder-free technology, surface quality is not compromised by the tool or bladder surfaces used in legacy forming systems. As water comes in contact with just one side of the metal surface, FluidForming is perfect for pre-finished materials and where die contamination is of concern. Trademarks, brands, and logos can all be easily incorporated into the design of each part.

FLEXIBLE DESIGN OPPORTUNITIES

Product designers can innovate freely and create highly integrated designs. Using its free-form design capabilities, FluidForming enables the manufacturing of parts with undercuts, organic shapes, or complex geometrical surfaces. Previously cost-prohibitive designs once molded in plastic can now be formed using strong, lightweight metals.

RAPID AND AFFORDABLE PROTOTYPING

FluidForming's revolutionary approach to metal forming enables companies to benefit from vastly reduced lead times and tooling costs. With FluidForming, 3D print tooling can be integrated, making it possible to move from CAD to production in days, rather than months! FluidForming is ideal for product development, prototyping, and low-volume fabrication.

HIGHLY ITERATIVE

Thanks to low tooling costs and 3D-printed tool compatibility, FluidForming is a highly iterative process, which allows for improvements to existing designs. Engineers also have the opportunity to integrate multiple parts to form organically shaped surfaces and can even potentially iterate within the same tool, producing multiple parts in the same tool set up.

TOOLING ADVANTAGES

FluidForming's approach to metal forming allows for modular and/or nested die design. Because instantaneous stamping forces are not introduced into the frame or structure of the FormBalancer machine or into the foundation of the supporting floor, as they are with legacy hydroforming methods, options for modularization or nesting of tooling exist. Because tools can be nested, parts that were once considered too complex for hydroforming (undercuts, logos, and sharp angles, for example) can now be formed. This serves the dual function of reducing production time and minimizing tooling costs.

FluidForming also presents an opportunity to move away from costly and time-consuming steel tools. FluidForming enables the use of easily machinable hard plastic, engineered wood, composites, or any other hard material with low compressibility. 3D-printed tools or other additive manufacturing methods such as selective laser sintering work well with the technology.

UNSURPASSED QUALITY, ACCURACY, AND REPEATABILITY

With a 99.996 first pass yield success rate, FluidForming offers the quality, accuracy, and repeatability that manufacturers can rely on. Because only one surface of the sheet metal is subjected to a flexible and self-adjusting tool surface (recycled water), the sheet metal will be forced into the tool and onto the tool surface. The resulting part will have little to no distance between the tool and metal surface, resulting in a highly accurate part. FluidForming's high forming pressures also help ensure that the completed part experiences virtually no warping or springback. This, in turn, minimizes post forming fixturing and clamping. The Advanced Element Analysis feature allows for the evaluation of part design prior to tool build.

In addition to the high degree of accuracy, the process is highly repeatable. Figures 1 and 2 show production accuracy and repeatability. The individual data points refer to respective maximum negative and positive distance deviation from the design CAD model of the part.

Figure 1

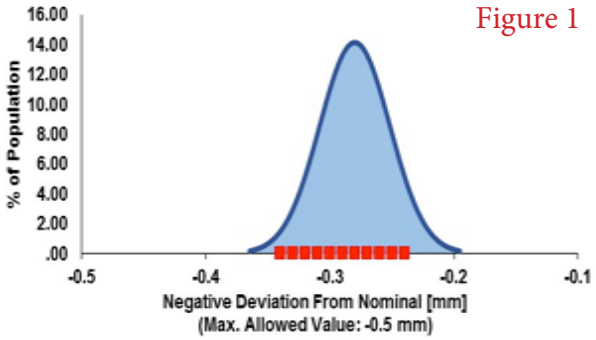
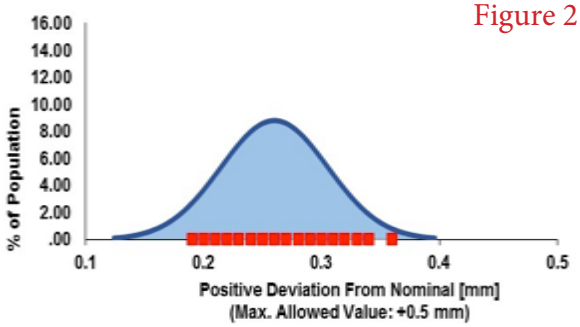


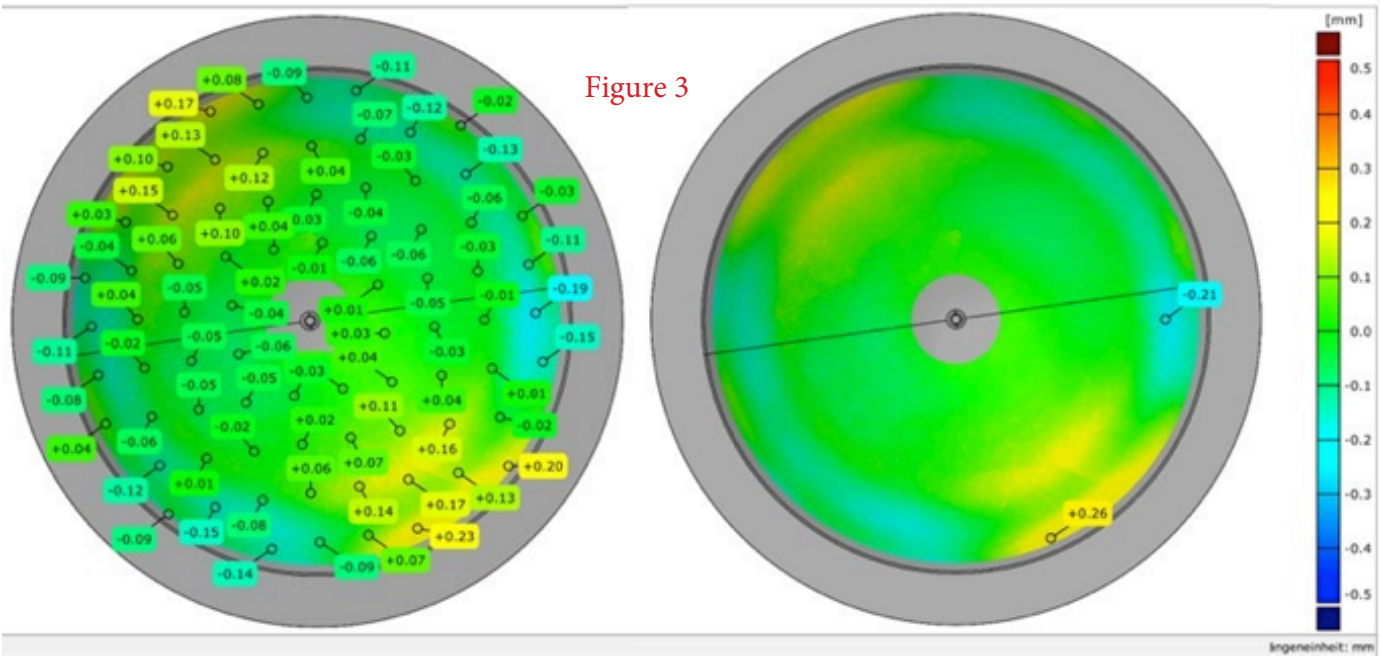
Figure 2



It's worth noting that part-to-part variation of the surface dimensions may be due to a number of causes; however two of the most common are metal springback and variations in the sheet metal wall thickness. Springback is minimal with FluidForming and can be compensated by appropriately deepening or changing the tools surface, if necessary. Part springback and warping results in FluidFormed parts are an order of magnitude better (lower) than those typically found in an equivalent die stamping part.

In Figure 3, a typical measurement result is shown for the deviation of the actual part surface dimension from the CAD design surface dimension.

Figure 3



This accuracy results in minimized downstream operations like fixturing and clamping and can translate into considerable cost reductions. In certain situations, where the highest degree of accuracy is required, an intermediate or additional annealing step using the same die will yield even better results.

The Profound Implications of FluidForming

While the physics of FluidForming are pretty straightforward, the implications of this new alternative to metal forming are profound. FluidForming has the potential to:

- **Enable improvements in existing designs.**
- **Open up the possibility of forming previously cost-prohibitive designs in metal (many plastic injection moulded parts can now be formed out of metal)**
- **Form components out of a variety of metals and alloys like titanium, copper, aluminum, and stainless steel.**
- **Create new opportunities in the medical, automotive, and aerospace industries.**
- **Dramatically reduce product development cycles and time to market.**
- **Minimize overall production costs.**
- **Encourage product design and innovation**

Conclusion

Thanks to higher forming pressures and our compact, force-contained FormBalancer machine, the FluidForming process makes it possible to form complex, highly-detailed, and highly-repeatable parts at an overall cost that is significantly lower than those produced by conventional, die-based metal stamping or bladder-based hydroforming. Nested, split, and multi-cavity tools provide cost-effective ways to produce small part families.

Conveniently, the FormBalancer is a university sheet metal and tube forming machine. The only one of its kind, in fact. No additional foundation requirements are necessary, which results in flexible floor placement options.

FluidForming was designed with rapid prototyping and low- to medium volume production with the ability to mass produce in mind. Manufacturers enjoy shorter time-to-market and lower overall cost-to-market ratios. Because the FluidForming system enables the transition from CAD to 3D-printed tooling, companies are able to move from design to production in days rather than weeks or even months.

FluidForming enables innovation by dramatically lowering tooling and production costs, reducing production times, and by eliminating the need for environmentally harmful and costly hydraulic fluid.

To learn more about the principles of FluidForming and to find out how to put the FluidForming technology into your plant, contact FluidForming Americas today at **(800) 497-3545**, visit our website **www.ffamericas.com** or email us at **info@ffamericas.com**.